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Studying the Engineering Properties of the Remnants of Stone Cutting Factories (RSCF) According to the Industrial and Construction Requirements

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Abstract

Rock is one of the most important natural resources in construction works. Rock is usually cut from quarries and transported to stone cutting factories that located in several different cities in Yemen; the study region was in Ibb city. The process of cutting rocks in the quarries is accompanied with the rise of large amounts of dust, which causes air pollution in the surrounding areas and consume large quantities of fresh water meanwhile people who are living in this place do need this amount of water, and the process of cutting and refining stones made heavy and sticky residues, this residue is mixer of water that used for cooling the cutting saw with stone remaining that hang with water during the cutting and grooming process.

In addition to dumping the remnants of stone cutting factories in agricultural land and on the roads, sides is a permanent threat to the environment, humans, and animals.

In this study, has been studied the engineering properties of the liquid residues (RSCF) were analyzed and dried and subjected to different experiments as a type of soil.

The study was conducted on several characteristics including moisture content, liquidity, plasticity, weight, specific density, permeability, length and volume shrinkage, strength characteristics of cohesion and angle of internal friction. Aggregate analysis and classification of the soil from the studied material were carried out according to the AASHTO system. Also, the possibility of using the quarry residues in various engineering fields has been investigated, thus enabling us to use or eliminate this material as a dangerous pollutant that threatens the environment in the Republic of Yemen.

Keywords: Soil, RSCF, environmental pollution, industrial and structural applications, engineering characteristics.

INTRODUCTION

The rock in Yemen is one of the most important natural sources of construction. The Yemeni stone, which is produced from the finest stones in the world in terms of characteristics and colors, is considered to be compatible with all international standards and specifications. The stone industry is considered one of the most important industries in the Republic of Yemen because of its great economic benefits, especially its contribution to the national income and providing it to more than 50,000 jobs for Yemeni citizens, especially in the northern regions. Where the rocks are excavation from the quarries in different ways and then transferred to factories and shears distributed in different parts of Yemen, especially in the northern regions. The process of excavation rocks from quarries and moving them directly to saw blades is usually accompanied by large amounts of dust and disturbing sounds. Which causes air pollution and disturb the population in the surrounding areas, as well as the process of cutting rocks in factories consume large amounts of fresh water needed by the population of Yemeni cities and villages.

The process of cutting and refining the stones results in sticky and heavy residues called (RSCF) and consists of quantities of water used to cool saw blades and fine cuttings that are attached to the water during cutting and grinding.

After exposing the (RSCF) to sunlight and drying it becomes very light material and can be transported by air to different places. It may enter the human respiratory tract causing many diseases. In addition, the dumping of (RSCF) into agricultural land and on the roads is a constant danger to humans and animals because of the occurrence of some children and animals in some of the marshes that result from the accumulation of rubble around them.

The interest in (RSCF) began to emerge after the spread of the stone cutting industry in Yemen was considered to be one of the negative effects of this industry on the environment. But

because of the importance of this industry on the Yemeni economy and the lack of possibility to be dispensed with, has begun some studies to identify the engineering properties of (RSCF), other studies followed in most Arab countries.

PROBLEM STATEMENT

The quarry residue is considered one of the most dangerous industrial pollutants on the environment in the Republic of Yemen, because it is thrown randomly and unfairly on the sides of the roads and in the rainwater and sewage water and also on the agricultural land and this causes many problems as these effects directly affect the vegetation And the presence of animals in the areas where it is also causing air pollution and groundwater and the direct effect on the acidity in the agricultural soil, and do not forget that they are working to create a solid layer in the soil of agricultural soil to prevent access to water to the ground and water Groundwater, and there is also a significant effects on the human respiratory tract caused by the remains of quarry material transition of after drying by air to remote areas.

This study is special to the study of the problem of quarry residues in the stone cutting (RSCF) factories in Yemen. This is the first attempt in this field according to the researcher's information, in order to answer the following questions:

1) What are the properties of quarry residue?

2) Are quarry residues clay or sandy soil?

3) What is the possibility of using quarry residues in different industries?

4) Can environmental pollution resulting from quarry residue be disposed of?

In order to answer these questions, the researcher assumes that the quarry remains (RSCF) after a haze becomes a dirt material with specific characteristics that may be similar and may differ from the characteristics of clay soil and sandy soil because they contain large quantities of rock minerals and different percentages of chemical compounds, especially calcium carbonate cacl3. The researcher also assumes that the quarry residue material can be used if properly treated.

SIGNIFICATION OF STUDY

Because of the absence of a real strategy in the Republic of Yemen to get rid of the problem of pollution caused by the material of quarry residues (RSCF), and because of the absence of scientific studies and actual to examine the characteristics of this material and the possibility of use in different industries or disposal as an environmental pollutant, this study to contribute to complete some of the lack of this aspect and to be the beginning of many future studies that will reach a final solution to this problem.

As we can see, the real problem is that the remains of the quarries (RSCF) are transformed from sticky liquid residues into solid (dirt) residues that are not used after water has evaporated.

This study is the first of its kind at the level of the Republic of Yemen, which examines the engineering properties of quarry residues and the possibility of benefiting from them in manufacturing and disposal as an environmental pollutant in order to preserve the continuity of this industry in its present form and to benefit from the waste produced in all aspects and preserving the environment Human and animal life and agricultural land.

SCOPE OF STUDY

All stone factories and saws distributed in the northern regions of the Republic of Yemen, specifically in Ibb province, can be considered the studied society.

It should be noted that the results of the study are directly related to their samples as the material of the quarry residues in the Yemeni areas contain a high percentage of calcium carbonate (CaCo3), which in most quarries reaches (90%) of the metal structure of the stones and this depends on the origins of the geological formation of the sedimentary rocks of stones Itself, as the higher the percentage of (CaCo3) in the original rocks through which the stones are produced the more quarry residues the more quality because (CaCo3) is a chemical compounds that enter in many industries, especially in the cement industry, plastics and materials Heat and Sound insulation, as well as paints, rubber, and decoration materials as well as all the materials, are not load to high stresses.

The experimental method was followed in this study, where many experiments were tested in the laboratories (University of Sichuan). The results of laboratory experiments were analyzed, presented and discussed in a scientific manner, the validity of the hypotheses of this study.

Laboratory Experiments

A lot of quarry residues (RSCF) were collected from different sites in the northern regions of the Republic of Yemen and specifically from Ibb province. Samples were collected from the exit point of the asthma material from the cutting saws and factories directly and then transferred to laboratories for soil experiments.

Figure 1 Shows a picture of the waste of the stone cutting factories (RSCF)

As they are removed from the stone cutting saws directly and disposed of in the proposed lands.

The first step in the preparation of the different samples was to dry the quarry residues in the drying kilns under a constant temperature of 110 ° C for 24 hours, then grind them using a special mill and then placed in the sieve apparatus to be sown according to the required granular gradient For all required experiments.

Figure 2. Shows the image of the remains of the quarries after drying and grinding

It is noted that the dry residues from the furnace are characterized by their weak cohesion in the form of blocks. This may be due to the evaporation of the water from the fine particles forming and shrinking which leads to the adhesion of the granules with each other. In addition, there is a high percentage of (CaCo3) which resulted in the residues are calcareous sedimentary rocks. Laboratory tests conducted on the samples included the following experiments:-

Natural density, softness or liquidity limit, plasticity limit, residual analysis, longitudinal and volume shrinkage, specific and relative density, direct shear, permeability, axial pressure not confined to asthma samples treated with cement materials (ASTM).

Results of Laboratory Tests

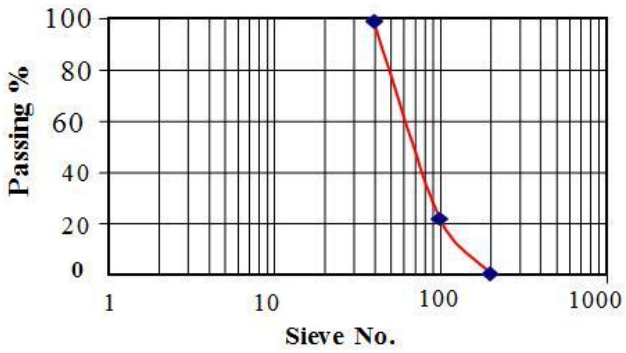

Figure 3. Shows the granular gradient curve of quarry residues

The experiment was conducted on the three sieves 40, 100 and 200, the similarity factor was 1.35 and the bending factor was 3.17, and the ratio of effective volume (D10) was about 19%.

Based on the experience of sieve analysis and the experience of the liquidity and plasticity limit, we were able to classify the quarry residue according to AASHTO method and found that it belongs to the group (A-2-6 (0)), and it was classified according to the standardized classification method and were found to (White Silty Sand Mixture) SM.

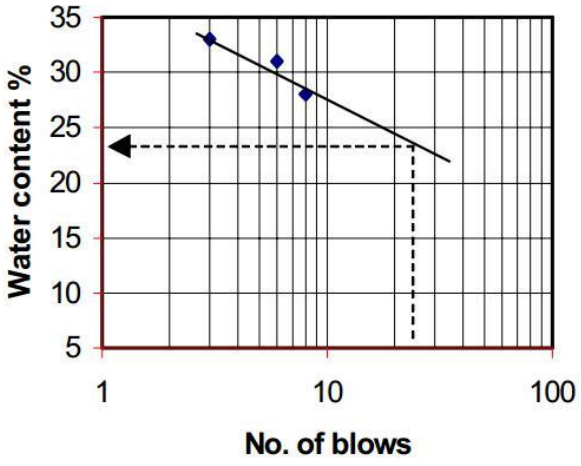

Figure 4. shows the plastic limit curve of quarry residues

Figure 4 shows the plastic limit curve of quarry residues and was found to be about 22%, the direct shear box experiment on the samples of quarry residues was done on samples prepared at density 1.5 g / cm3 and moisture content of 10%, tested at progressive vertical stress From 0.755, 1.02, 1.312 and 1.859 kg/cm 2, respectively.

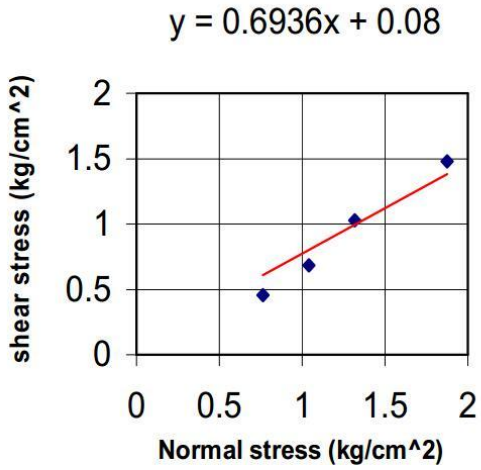

Figure 5. shows the result of the direct shear box experiment

Figure (5) shows the result of the direct shear box experiment on the quarry residue samples where the internal friction angle was found to be 34 ° and the bonding coefficient 0.08 kg/cm2.

The permeability pressure Constant test was conducted on a sample prepared under standard laboratory conditions at density 1.51 kg / cm3, The sample height was 11.45 cm and 10 cm diameter and the permeability coefficient was equal to k = 3.4x10-8.

Where the density of the sample for permeability testing differs slightly from the sample density of the direct shear box experiment. This is due to the difference in the mold in which the sample of the experiment was prepared and the difficulty of obtaining the same density in the permeability testing sample. The density was 1.6 kg / cm3 is very close to 1.51 kg/cm3 (because the volume of the void was closed e, Void, Ratio), the result of the permeability experiment will be less than obtained in the case of permeability testing at density 1.51 kg / cm3, Showing a summary of the results of laboratory experiments conducted on the (RSCF).

We note from Table (2) that the value of the maximum pressure stress increases by the percentage of cement and there was little change in the pressure stress due to the increase of the percentage of iron filings (Fe) during the period of 14 days of preparation of samples.

We would like to notes that iron filings (Fe) has been introduced for the purpose of disposal as waste from steel mills and to improve the properties of quarrying (RSCF).

Table 1 Summary of laboratory test results

Name of Test	Result
Natural Water Content	63%
Sieve analysis parameters	Cu=1.37,Cc=3.19,D_{10}=0.091 D_{30}=0.19,D_{60}=0.29
Liquid Limit	23%
Shrinkage Limit, Linear, Volumetric	5.7%,26%
Plastic Limit	non – plastic
Specific gravity	2.46
Maximum Density (Wet, Dry)	1.73g/cm^3
Shear Strength Properties, □, C	34^o , 0.08kg/cm^3
Constant Head Permeability, k	$3.4x10^{-8}$ m/s (Density = 1.51 g / cm^3)
Soil Classification Group (AASHTO, Unified system)	Light white sandy Silt Mixture A-2-6(0) , SM

Table 2 Results of the axial pressure experiment to (RSCF) sample

No. Sample	Diameter cm	Height cm	Volume cm^3	Weight gm	Density gm/cm^3	Iron filings % : Cement	Maximum Stress	Strain %
1	3.78	8.70	97.63	153.99	1.58	0-0	2.64	0.86
2	3.73	8.06	88.10	144.72	1.64	0-0	2.71	0.83
3	3.73	7.76	84.10	135.45	1.60	0-0	1.52	0.43
4	3.72	8.54	92.82	146.83	1.58	0-0	2.02	0.83
5	3.81	7.90	90.10	166.12	1.84	0-7	3.94	1.20
6	3.73	8.31	89.35	170.71	1.91	0-7	3.30	0.93
7	3.73	9.76	106.65	202.52	1.90	0-7	4.58	1.20
8	3.80	8.78	99.58	177.24	1.78	0-7	3.10	0.88
9	3.79	9.84	111.01	195.52	1.76	5-0	8.13	1.99
10	3.81	8.81	100.44	175.62	1.75	5-0	6.27	1.86
11	3.80	9.75	110.58	195.63	1.77	5-2	4.97	1.37
12	3.80	7.82	88.69	158.37	1.79	5-2	7.82	2.52

RESULT AND CONCLUSIONS

A lot of experiments have been conducted in this study to identify the engineering properties of quarry residues (RSCF), which are liquid wastes resulting from the cutting and grinding of building stones. It has been found through this experiment that this material has intermediate properties between the soil and sandy soils. And the most important of these results reached:

1- The internal friction angle is 34^o degrees and the coefficient of cohesion 0.08 kg / cm^2 at a density of 1.6 kg / cm^3, and these results are good for the use of quarry residues (RSCF) in some structural applications such as the manufacture of different types of blocks and tiles that are not subjected to high stresses.

2- The permeability coefficient is $3.4x10^{-8}$ m / sec at a density of 1.51 kg / cm^3. This is a very important feature where quarry residues (RSCF) can be used in some applications that do not require high permeability such as lining the waste dumps to prevent leakage into the groundwater. To cover the waste on a daily basis at those dumps, and can be used to construct roads to prevent rainwater intrusion from the road surface and its aspects to the sub-grade layer.

3- The quarry residue (RSCF) was classified according to AASHTO method and was found to belong to A-2-6 (0). And it was classified according to the standardized classification method and was found to belong to the (White Silty Sand Mixture SM) group.

(RSCF) are non-plastic material (their properties are close to sandy soil characteristics).

4- The specific density of (RSCF) found 2.46, volume and longitudinal variation 26% and 5.7% respectively, natural moisture content is 63% and the liquidity ratio is 23%.

5- The use of cement and iron filings to improve some of the properties of quarry residues (RSCF), it was found from the experience of axial pressure is not limited to pressure stress increases the proportion of cement, while not significantly affected by the use of up to 7% of iron filings.

6- Through our findings in this study it can be said that the material of the remains of quarries (RSCF) is a kind of soil that has characteristics of clay and sand and can be invested in many industries and construction works and this proves the validity of this hypothesis and answers to its questions, as well as we can get rid of the problem of environmental pollution caused by this material is final, If it is properly invested.

RECOMMENDATIONS OF THE STUDY

This study is the first attempt in this field (according to the researcher), and therefore the results reached are preliminary and limited results of the nature of the area and also the type of residues of quarries (RSCF) and rocks that produced it, the results in this study, especially those related to the engineering characteristics of the sample still need to confirm their values through the study of other types of quarry residences (RSCF) to other areas in the Republic of Yemen other than the studied area or in other areas of neighboring countries, as well as to study the possibility of using quarry residues (RSCF) in other fields not mentioned in this study, Heat and Sound insulation workers, as well as the work of the interior and exterior finishes of buildings.

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